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Abstract

Functioning in our everyday lives requires that humans rely on organizing and categorizing our world. This ability to categorize rests on object individuation, the ability to track the identity of objects when they leave and reenter sight. Objects can be individuated using three types of information: spatiotemporal, object property and object kind. Surprisingly, noun comprehension may affect infants' use of object kind information (Xu 1999; Xu 2002). However, research using a comparative approach suggests that the ability to use kind information to aid in object individuation may not be unique to humans: great apes, rhesus monkeys and dogs all successfully individuate objects using spatiotemporal and property/kind information (Brauer & Call 2011; Phillips & Santos 2005; Uller 1997). Little is known about non-linguistic animals' ability to individuate objects using kind information alone. Here we explore the effect of a language cue on dogs' ability to use kind information for object individuation. We recruited 24 dogs to participate in a violation of expectation paradigm and subsequently analyzed mean looking times in expected versus unexpected outcomes. Results did not support our predictions: dogs looked equally long at expected and unexpected outcomes for all individuation cues. However, our methodology may have lacked appropriate controls, thus future research into this topic is warranted.

Keywords: object individuation, perception, dogs, *Canis familiaris*, spatiotemporal information, object property, object kind

This or that?: Object individuation in domesticated dogs (*Canis familiaris*)

Adult humans encounter a variety of objects throughout the day. For example, one may encounter two very different objects, such as a truck and a toy duck. Our perceptual and cognitive mechanisms allow us to recognize and individuate these as discrete objects: to recognize that the truck and the duck are different from each other and are not the same type of object. This ability to categorize objects as distinct allows us to make inferences about the way an object may act or how we may act upon objects. A truck is useful for moving around places or transporting objects, while a toy duck is useful for entertaining a child or storytelling. While the origins of this object individuation are still being determined, we do know that adult humans use at least three sources of information in order to individuate objects: spatiotemporal, object property, and object kind information (Xu, 1999).

Spatiotemporal information involves the generalizations we make about an object's location in space and its path through time (Xu, 1999). For example, one object cannot be in two places at the same time, nor can two objects occupy the same space at the same time. Imagine you see a red truck drive down the street in front of you and it turns right at an intersection. If immediately after the truck is out of sight you see an identical red truck drive past you from the opposite side of the intersection you would not infer that it was the same truck; you would necessarily infer that there are two identical but discrete trucks as their paths did not cross or align spatially.

Object property information includes the use of featural elements of an object, such as its color, size, and shape to aid in object individuation. The way that human adults use object property depends on our knowledge of category. Thus, information about the *kinds* of objects things are can inform our criteria for object individuation using object property information.

Object kind information refers to the knowledge we have about specific categories that objects belong to. Our knowledge about specific categories also allows us to make inferences about what featural properties of an object require our attention in that category. For example, a red truck cannot also be a blue truck without being painted. Imagine you see a red Toyota truck in your neighbor's driveway all the time and one day the truck in the driveway changes to a blue Honda truck. You know that your neighbor must have purchased a new truck. However, now imagine you have a real pet duckling living in your house. She is yellow all over and weighs less than a pound. Now you leave your house and your roommates to take care of your duckling for a few weeks. You come back and your duckling has grown in size and is now yellow and grey. You know it is the same duckling you left because real ducks molt their feathers and change colors during their development. Thus, similar changes in the properties (color, shape) of your neighbor's truck and your pet duckling lead you to infer two different things about the identity of the objects.

It is still largely unknown what kinds of cognitive and perceptual mechanisms facilitate adult humans to use the relevant information provided in each type of cue. Things like color perception and binocular vision aid in our perception of the informative cues aforementioned while attention and memory allow us to store this knowledge. However, little is known about the cognitive mechanisms required for object individuation using kind information alone. While the use of the informative cues outlined above is well understood in adult humans, it is still unclear when during development children start to understand these cues, and what promotes the development of this ability (Xu, 1995).

Recent research has shown that infants as young as 4 - 10 months old readily use spatiotemporal information to aid in object individuation, but it's not until 12 months of age that

they use object property and object kind information (Rivera and Zawaydeh, 2006; Xu, 1996; Xu, 1999, Xu & Baker, 2005; Xu, Carey and Quint, 2004; Xu, 2007; Xu, Cote, and Baker, 2007). To come to this conclusion, researchers have used looking time measures to assess infants 'surprise' when three informative cues—spatiotemporal, object property, and object kind—were violated. For example, to test 10 and 12 month old infants' ability to use spatiotemporal information in object individuation, researchers measured the looking time of infants who saw a toy duck removed from each of two occluders and then appear to move magically between them. The infants did not directly observe the movement, rather they only saw the unexpected outcome of just one toy duck behind an occluder. This violated the spatiotemporal continuous path, as the occluders were separated by about a foot, and the toy duck did not pass through the open space between them. Infants looked significantly longer at this outcome compared to a control condition in which the duck did not move between the occluders (Figure 1). Similarly, to test the infants' ability to use object property information, researchers measured the looking time of infants who first saw a toy duck removed from behind an occluder and then replaced behind the occluder. Infants then saw a toy truck removed from behind the same occluder, replaced, and finally, researchers removed the occluder to reveal only a toy duck, but no toy truck, behind it. Infants looked significantly longer at this outcome compared to a control condition in which both the duck and truck remained behind the occluder (Figure 2).

Ten month old infants successfully individuated the toy duck —i.e. looked longer at the outcome in which spatiotemporal information was violated—when spatiotemporal information was provided, but failed when only object property information was provided—i.e. looked equally as long at outcomes where property information was violated or maintained. However, 12 month old infants were able to successfully individuate the objects in both conditions (Xu,

1996; Xu, 1999). These findings suggest that 12 month old infants understand how to use object property information whereas 10 month old infants do not. Because no spatiotemporal information was provided in the second example, when objects remained behind a single occluder, successful object individuation required the use of object property information alone. It is possible that 10-month old infants did not share the same expectation violation as 12 month old infants because the 10 month old infants rely exclusively on spatiotemporal information for object individuation. Thus, 12 month old infants' expectations were violated when the physical properties of the toy changed behind the occluder without evidence of an actual change in the toy by the experimenter while 10 month old infants were unable to detect this change.

The change in infants' ability to use object property and object kind information seems to occur relatively rapidly over the course of two months. However, there is a correlation between the acquisition of infants' ability to individuate objects using property/kind information alone and their burgeoning language development. This correlation suggests an important role of language development in infants' ability to use kind information for object individuation (Balaban & Waxman 1996; Xu 1999; Xu 2002; Xu, Cote, & Baker 2007). Interestingly, noun comprehension may have an effect on this developmental difference. In her original study, Xu (1999) used preliminary data from parental reports of noun comprehension to show that 10 month old infants who did not know any or knew just one of the words for the items in the individuation task (neither truck nor duck or only one of the two) failed at using object property/kind information whereas those that knew two or more words succeed in the task (similar to 12 month old children, 85% of which understood 2 or more of the words). This suggests that having words for objects may help infants individuate kind categories in their

environment and allow them to use kind membership for object individuation in property/kind tasks.

Further studies have also suggested the importance of language on kind categorization and object individuation. These studies demonstrate that nine month old infants succeed in object property/kind individuation when given two distinct labels for items, but do not succeed when the same label is used for both objects or when tones, sound, or emotional expressions are used as labels (Balaban & Waxman 1996; Xu, 2002; Xu, Cote, & Baker 2007). For example, only when given the distinct cues, “Look, it’s a truck. Look it’s a duck” are 9 month old infants able to successfully individuate a toy truck from a toy duck in the absence of spatiotemporal information. Conversely, when given cues like: “Look it’s a toy. Look it’s a toy.”, two distinct tones—a D sharp note and a C note one octave higher—or two distinct emotional expressions—“Ah!” or “Ewy!”—nine month infants fail to individuate objects (Xu, 2002). Xu (2002) hypothesized that language may play a role in infants’ acquisition of object kind concepts and that words, whether known or unknown, may serve as “essence placeholders” which convey simple information about objects for individuation, but do not yet represent a complete object kind concept.

The role of language in human representations of object kind concepts is still relatively unknown. In order to tease apart object kind concepts from object property concepts embedded in them, superficial or non-necessary properties of an object can be manipulated while maintaining the kind distinction of the object (Mendes, Rakoczy & Call, 2007). For example, ten year old children understand that if a raccoon is shaved and painted like a skunk it still remains a raccoon even though its physical properties now resemble those of a skunk rather than a raccoon (Keil, 1989). Thus, a language cue can be used as a superficial and non-necessary property of an

object to provide cues about its kind category without physically changing the object's properties. In other words, if the same toy duck is labeled as both "Blicket" and "Dax" as it arises from behind an occluder then we might predict that human infants would expect to see two toy ducks behind the occluder when it drops, one representative of the cue "Blicket" and one representative of the cue "Dax".

If language is important for human infants' development of the ability to use kind information to individuate objects, then it is reasonable to expect that non-human animals without language may be unable to use kind information alone to individuate objects. However, research with other species has demonstrated that use of object property/kind information for object individuation is not uniquely human (Brauer & Call 2011; Mendes, Rakoczy & Call, 2007; Phillips & Santos 2005; Santos, Sulkowski, Spaepen & Hauser, 2002; Uler, Carey, Hauser & Xu, 1997). Three great ape species, rhesus monkeys, and cotton top tamarins successfully used spatiotemporal and object property information to individuate objects (Brauer & Call 2011; Medes, Rakoczy & Call, 2007; Santos, Sulkowski, Spaepen & Hauser, 2002; Uller, Carey, Hauser & Xu, 1997; Xu 2007). For example, in the spatiotemporal case researchers showed the monkeys that one squash and one carrot piece went into a box together and were not removed. Monkeys were allowed to search the box and should have expected to find one piece of each food. In the object property case researchers showed the monkeys one carrot piece (orange, long and cylindrical) going into the box and then one squash piece (yellow, curved and flat) going into the box. The monkeys then expected to find one carrot piece and one squash piece because they seemed to understand that a carrot cannot turn into a squash, and thus there must be two physically different objects in the box that match what was originally put in individually by the experimenters (Uller, Carey, Hauser & Xu, 1997). Rhesus monkeys were able to successfully

individuate a piece of carrot from a piece of squash—that is they searched longer in the box when there were two pieces of the same food rather than one piece of each food—using spatiotemporal information when the carrot and squash where shown going into a box at the same time, and object property information when the carrot and squash where shown going into the box separately (Uller, Carey, Hauser & Xu, 1997).

These studies provide evidence that non-linguistic species can successfully individuate objects using object property information. However, little is known about their representation of object kind concepts. It is unclear whether the monkeys were using object property information of carrots and squash (i.e. the carrot piece was bright orange, straight, 22 centimeters long and 3 centimeters in diameter while the squash piece was bright yellow, curved and 20 centimeters long) or if they were using kind information such that they have a cognitive representation of carrot pieces versus squash pieces, possibly based on previous experience with the taste, appearance, and use of each object (Uler, Carey, Hauser & Xu, 1997). To explore this, Phillips and Santos (2005) showed that rhesus monkeys successfully individuate different kinds of objects even when their properties are held constant, suggesting that non-human primates do possess kind representations. As nonhuman primates do not have linguistic labels for squash and carrots this suggests that linguistic labels are not required for kind representations; however, it is still unclear *how* non-human animals represent kind distinctions and whether this representation is similar to our own (Phillips & Santos, 2005).

In order to better assess the mechanisms, and the development of these mechanisms, that aid in object individuation by humans and non-human animals, it may be helpful to study object individuation in a subject species that shares some features of language acquisition like the infants, but is not completely linguistic. Domesticated dogs, *Canis lupis familiaris*, may provide

an effective way to investigate how non-human animals represent kind distinctions and how it relates to our own ability. Through the process of domestication, dogs have developed the unique ability to learn associative values for words quickly by virtue of their relationship with humans. This sensitivity to words can allow us to use non-meaningful language cues to portray categorical or kind information about an object to dogs while retaining the same property information. Using this language cue will help elucidate the differences or similarities between dogs' and humans' representations of kind distinctions when tasked with object individuation.

Importantly, domesticated dogs have been shown to possess the ability to "fast map" words (Kaminski, Call & Fischer, 2004). Fast mapping is the ability children develop during speech acquisition to form quick and rough hypotheses about the meaning of new words only after a single exposure. For example, a child who has never seen gloves before, but has experience with and knows the words for scarf, hat and coat is probably able to still retrieve gloves from a pile of winter outerwear when asked for gloves by a parent: gloves are the outerwear that they do not already have a name for. Dogs seem to possess cognitive mechanisms to do the same kind of fast mapping as human children (Kaminski, Call & Fischer, 2004). For example, a dog named Rico when asked to retrieve a novel item from a pile of toys he already had labels for was able to link the novel label with the novel item. If Rico knew which toys were "Rabbit," "Raccoon," "Duck" and "Squirrel," but not "Moose", he was able to infer which object was "Moose" by exclusion: it was the label that goes with the toy that is not labeled "Rabbit", "Raccoon", "Duck", or "Squirrel". He could then bring the novel "Moose" to his owner. Rico may have known which toy to fetch because he excluded all of the other toys he already had labels for, similar to fast mapping in human children. Additionally, Rico was able to store the new knowledge about the name identity of toy because he was able to successfully retrieve the

target toy from a set of both novel and familiar items four weeks later (Kaminski, Call & Fischer, 2004).

In an object individuation study by Brauer and Call (2011), dogs showed similar behavior patterns and performed similarly to great apes when using spatiotemporal and object property information. For example, during individuation tests, both dogs and apes remained closer to an experimenter and begged more often in trials with unexpected outcomes than trials with expected outcomes. Unexpected outcomes are when the rules regarding informative cues being tested—spatiotemporal and object property—are not followed (i.e. a less desired food item magically took the place of a more desired food item without the subject seeing the change). Both dogs and apes also reacted similarly to positive food surprises (i.e. good food object had been substituted for bad food object) and negative food surprises (i.e. bad food object substituted for good food object) (Brauer & Call, 2011). The similarities in behavior and responses between great apes and dogs suggest that object individuation, based on spatiotemporal and object property information, may be a basic skill possessed by many mammal, or even animal, species.

Pet dogs also experience similar environments to human infants and share, in some ways, a similar baseline exposure to language from their owners as infants from their parents. Dogs are often exposed to the same kind of praise, tone and type of speech that infants are. However, dogs lack the ability to develop human language and manipulate language in the same way that humans do (Hauser, Chomsky & Fitch, 2002). It is possible that the exposure infants experience during development promotes their development of object individuation using kind information. Thus, domesticated dogs provide an excellent study species to explore the effect of language cues and language acquisition on object kind individuation when object property information is held constant.

We aim to replicate the results of Brauer and Call (2011), using a modified looking time task to show that pet dogs do possess the ability to individuate objects using spatiotemporal and object property information. Additionally, we predict that when property information is held constant and a unique language cue (label) is given, dog's will be able to use object kind information alone, portrayed by the language cue, to successfully individuate objects. This experimental procedure demonstrates an expected event which, if dogs understand the relevant cues, should be in line with their perceptual and cognitive expectations (resulting from feature detection, short term memory, etc.) and an unexpected event which, if dogs understand the relevant cues, should violate the informational cues being tested (spatiotemporal, object property, and object kind). Infants and non-human animals usually look longer at unexpected events compared to expected events suggesting that they detect the violation and are surprised by the outcome.

We are employing a looking time version of this study because preliminary research into this topic through pilot testing dogs showed that dogs were at ceiling when allowed to search and interact with food items that they were individuating in testing trials. In other words, dogs spent the entire time allotted searching inside the box in each outcome resulting in an inability to determine whether they were surprised in violation conditions compared to expected. Similarly, because we ultimately aim to test dogs' ability to individuate when property information is held constant and only kind information is provided by a unique language cue, we required a method that allowed property information to be held constant. If dogs were able to interact with a food item as the dependent variable they may have picked up on property information like smell and texture which would interfere with their use of the language cue.

I predict that when object property information is held constant and object kind information is manipulated by the presence of a distinct language cue, dogs will successfully individuate objects. For example, when the same toy is labeled with two different cues I predict dogs will expect to see two of the same toy, one for each label, behind an occluder rather than only one toy. This prediction is supported by findings from Brauer and Call (2011) and Phillips and Santos's (2005). Assuming that dogs will respond to an object individuation task similarly to primates, as suggested by Brauer and Call (2011), dogs should be able to use object kind information alone to individuate objects as the rhesus macaques portrayed this ability in Phillips and Santos's (2005). The prediction is also supported by infants' ability to use object kind information later in development after some language acquisition, as pet dogs and infants share similar exposure to language input in their environments (Balaban & Waxman 1996; Xu 2002, Xu, Cote & Baker, 2007).

Method

Subjects

24 domestic dogs (*Canis lupis familiaris*; thirteen females and 11 males, age range 5 months-12 years, $M = 6.50$, $SD = 3.70$) were recruited from the Illinois Wesleyan University Dog Scientist database (Appendix A). Nine dogs were excluded because the experimenter could not get their attention (5), their owner interfered (1), they were too anxious to participate (1), their owner disclosed impaired eyesight after testing (1), or they barked during all looking periods making it impossible to code looking (1). Nine dogs were excluded from just one condition (one spatiotemporal, four property, three kind with language, and one kind without language) because the experimenter could not get their attention, but these dogs participated in the other three conditions.

Materials

The looking time (LT) apparatus was constructed out of foam core and measured 23 cm wide X 51.5 cm long X 47 cm tall (Figure 3). The apparatus consisted of a stage in front of an all-white background, 51.5 cm long x 33 cm tall, with two sides, 23 cm long x 47 cm tall and an attached retractable occluder, 51.5 cm long x 47 cm tall, to cover the stage during presentations of the stimuli. The stage had a false bottom which opened into an area under the stage to store the stimuli, 23 cm wide X 51.5 cm long X 14 cm tall. During testing trials toys were retrieved from the false bottom by removing the base of the stage and extending a hand into the storage compartment. They were then placed on the stage resulting in the desired outcome.

The stimuli used for presentation were a Fischer Price tote-along monsters baby toy model Harvey and a Bright Stars twiddle tweets toy. Sony HD video recording HDR-CX430 Handycam camcorder was used to record each trial. The camera was positioned directly to the right of the looking time apparatus facing the subject dog directly. The author and another undergraduate student analyzed videos of each dog in the lab to using MPEG Streamclip software and Microsoft Excel to determine mean looking times for the two outcomes for each dog in each condition. Reliability between these two coders was good ($\alpha = 0.84$).

Procedure

Dogs arrived at the Illinois Wesleyan Dog Scientists lab and were allowed time to acclimate to the lab and testing room while their owners spoke with the research assistants and signed a consent form. Each dog participated in eight trials during the study. There were four conditions each with two outcomes (expected and unexpected) resulting in 8 trials per dog: spatiotemporal (2), object property (2), object kind with language (2), and object kind without

language (2). The order of conditions and outcomes within conditions was counterbalanced across subjects.

Spatiotemporal

Dogs were brought into the testing room by experimenter 1 (E1). E1 restrained dogs in either a sit, stand or lay position approximately 2 meters and 40 centimeters away from the LT apparatus and facing the LT apparatus directly. Experimenter 2 (E2) knelt behind the LT apparatus with the occluder covering the stage and all stimuli in the false bottom compartment of the stage.

The two outcomes, expected and unexpected, were visually different and required familiarization trials to ensure that the dogs were not preferentially looking at one outcome in the testing trials. Dogs were familiarized with the possible outcomes before any informative cues were given about the objects. First, in the familiarization, E2 showed the dog two of the same Harvey model of toy on the stage (unexpected outcome), and then one of each Harvey and Twiddle Tweets model of toy on the stage together (expected outcome). Each familiarization lasted 10 seconds (Figure 4). E2 then cleared the stage and dropped the occluder, cueing the dog to look at the empty stage by saying “Dog’s name, look”. E2 left the empty stage displayed for 5 seconds before retracting the occluder (Figure 5). For the unexpected outcome E2 removed one Harvey and one Twiddle Tweets model from the false bottom and showed the subject both toys simultaneously by extending her arms in front of her and over the top of the LT apparatus (Figure 6). E2 again cued the dog by saying “Dog’s name, look” and displayed the toys for 5 seconds. E2 then repeated this display a second time. After the second display E2 placed the toys inside the LT apparatus and surreptitiously replaced the Twiddle Tweets toy with a copy of the Harvey toy so that two of the same Harvey toy were left on the stage at the end of the trial. E2 then dropped the occluder, averted her gaze, and allowed the dog to look for 10 seconds. This outcome was unexpected because it

violated the information portrayed in the presentation such that a Harvey toy now appeared on the stage rather than a Twiddle Tweets toy without any cue given to the dog about the movement of either toy. Thus, if dogs are tracking spatiotemporal information it would appear that the second Harvey toy magically moved onto the stage and the Twiddle Tweets toy magically disappeared from the stage. The expected condition was exactly the same except E2 replaced the Twiddle Tweets toy with an exact copy of itself to ensure that the movements of E2's hands were consistent across conditions. If dogs are tracking spatiotemporal information this outcome would be expected as it matched the presentation and toys the dogs saw in the presentation.

Object Property

The object property condition was identical to the spatiotemporal trial except that during the display the toys were shown one at a time as opposed to simultaneously (Figure 6). By showing toys one at a time this removed any spatiotemporal information present in the previous condition and forced the dogs to rely on only the featural properties of the toys to aid in individuation. During the display period E2 first removed the Harvey toy model and cued the dog. Then E2 put the Harvey model back into the LT apparatus and removed the Twiddle Tweets model and cued the dog. In the unexpected outcome E2 surreptitiously exchanged the Harvey toy for the Twiddle Tweets toy and dropped the occluder so that two Twiddle Tweets toys remained on the stage. The expected condition was the same except that the Harvey toy was exchanged for an exact copy of itself and one Harvey and one Twiddle Tweets toy model remained on the stage when E2 dropped the occluder.

Object Kind

The familiarization sessions for the object kind trials were one Harvey model toy on the stage and two Harvey model toys on the stage together (Figure 4). The object kind trial began the

same as the other two trials with the display of an empty stage. In this trial only the Harvey model of the toy was used to control for property information and the Harvey toys were shown only one at a time to control for spatiotemporal information. Thus, the object kind condition required dogs to rely solely on kind information provided by a language cue. In the test condition E2 removed one Harvey model, cued the dog by saying, "Dog's name, look. It's a dax" and placed the toy back on the stage. Then E2 removed the same Harvey model toy from the LT apparatus and cued the dog by saying, "Dog's name, look, it's a blicket" and placed the toy back on the stage (Figure 7). In the unexpected condition E2 left just one toy Harvey model on the stage and dropped the occluder and allowed the dog to look for 10 seconds. In the expected condition, E2 surreptitiously put another of the same Harvey model toy, from the false bottom, on to the LT stage and dropped the occluder. The control condition was exactly the same as the test condition with both unexpected and expected outcomes, except that there was no language cue given during the display and E2 only cued the dog's attention by saying, "Dog's name, look."

Results

We performed paired samples t-test to compare mean duration of looking in each outcome (expected or unexpected) in each condition (spatiotemporal, property, kind with language, and kind without language). We found no statistically significant differences between mean looking times in the two outcomes of any condition (Figure 8): spatiotemporal expected outcome (M = 2.60, SD = 2.06) and spatiotemporal unexpected outcome (M = 2.22, SD = 2.28); $t(22)$ = -0.74, p = 0.47; property expected outcome (M = 2.38, SD = 2.30) and property unexpected outcome (M = 2.75, SD = 3.04); $t(18)$ = 0.53, p = 0.60; kind with language expected outcome (M = 1.66, SD = 2.28) and kind with language unexpected outcome (M = 1.64, SD =

1.32); $t(20) = -0.05$, $p = 0.96$; kind without language expected outcome ($M = 2.13$, $SD = 2.26$) and kind without language unexpected outcome ($M = 2.42$, $SD = 2.29$); $t(21) = 0.72$, $p = 0.48$.

In an effort to reduce the variation in a post hoc analysis we averaged the looking times in unexpected ($M = 2.11$, $SD = 1.56$) and expected outcomes ($M = 2.40$, $SD = 1.93$) for the spatiotemporal, property and kind with language conditions. This analysis still failed to reach any significance $t(17) = -1.219$, $p = 0.240$.

Discussion

Here we aimed to first replicate the results of Brauer and Call (2011) to show that dogs possess the ability to use spatiotemporal and property information in object individuation and second, to expand this line research by investigating dogs' ability to use kind information alone, provided by a language cue, to individuate objects. We predicted that dogs would be able to individuate objects (i.e. look longer at unexpected outcomes) using spatiotemporal and property information as was found by Brauer and Call (2011), and that dogs would be able to individuate objects using kind information provided by a unique language cue when property information was held constant. We predicted that dogs would look significantly longer at the unexpected outcomes in the spatiotemporal, property, and kind with language conditions but that there would be no difference in looking time between the outcomes in the kind without language condition.

Our results did not support these predictions. Dogs did not look significantly longer at either outcome in any of the conditions. Data was collected within subjects, so a preference in looking at either outcome was controlled. In other words, every subject participated in every condition and saw every outcome. This way each dog's individual preference in looking at the apparatus was represented in both the expected and unexpected outcomes to ensure any

difference in looking was due to the outcome itself rather than differences in dogs represented in the sample. It is important to note that there was high variation in looking times for all conditions and all outcomes. Notably, the sample size in this study was small for looking time studies (24 dogs and not all dogs' looking time data could be used for every condition), however, in an effort to reduce the variation in a post hoc analysis we averaged the looking times in unexpected and expected outcomes for the spatiotemporal, property and kind with language conditions. This analysis still failed to reach any significance, suggesting that additional subjects in the sample may not have changed the results.

Our findings in the spatiotemporal and property trials directly conflict with the findings by Brauer and Call (2011). While the methodology employed by Brauer and Call (2011) is slightly different than our own—they used a "magic" cup featuring food items as the objects requiring individuation and also allowed dogs to interact with the cup after viewing the demonstration—we still expected to see similar effects in the use of these informative cues by dogs. It is possible that these methodological differences may have made the Brauer and Call (2011) study more motivating for dogs, thus tapping into their actual ability to use these cues more effectively.

While Brauer and Call (2011) may be the only current evaluation of dogs' ability to use spatiotemporal and property information in object individuation, other studies have successfully used the same violation of expectation method employed in our study to investigate the use of other perceptual mechanisms in dogs (Erdőhegyi, Gergely & Topál, 2009; Pattison, Miller, Rayburn-Reeves & Zentall, 2010; Pattison, Laude, & Zentall, 2013). The past success using this type of method indicates that the violation of expectation paradigm is able to detect perceptual and cognitive abilities in dogs. Importantly, the Brauer and Call (2011) results supporting

spatiotemporal and property/kind object individuation in dogs suggests that dogs do possess this capacity despite our study's inability to detect it. One explanation for this disparity is that our methodology varied slightly from those aforementioned which were successful in detecting subjects' surprise during violation trials. There is some evidence in developmental literature that behavioral dependent measures may result in different outcomes compared to looking time dependent measures (Diamond, 2001).

This difference in experimental outcomes on behavioral tasks compared to looking time measures present themselves in research involving the "A not B error". In the "A not B error" behavioral studies infants habituate reaching into location "A" to retrieve a toy and then observe the toy being move to location "B" but fail to reach for the toy in location "B" (Diamond, 2001). Interestingly, when looking time is used as the dependent measure in this topic of interest, infants do not show the same preference for looking at location "A". Diamond (2001) describes this difference in part due to the different cognitive processes that occur preceding goal oriented actions. These processes involved looking, planning, reaching and remembering (Diamond, 2001). Thus, it may be that differences in dependent measures can tap into different parts of the preceding cognitive process and present different experimental findings. While this finding predicts successful looking and unsuccessful behavioral responses from human children, it is unknown how this phenomenon would present itself in nonhuman animals. Thus, leaving open the possibility of an inverse effect in dogs such that they would be successful in behavioral measure, but unsuccessful in looking time measures.

Another methodological difference between the present study and other successful looking time studies involved the number of familiarization trials and outcome presentations. Our study featured two familiarization trials, one for each outcome, and only one testing trial of

each outcome, expected or unexpected (Erdőhegyi, Gergely & Topál, 2009; Pattison, Miller, Rayburn-Reeves & Zentall, 2010; Pattison, Laude, & Zentall, 2013). This experimental design allowed us to test all four conditions (spatiotemporal, property, kind with language, kind without language) within subjects to control for individual differences in looking preferences. However, this design also meant that we had to minimize familiarization trials and outcome presentations to retain subjects' attention, potentially compromising the sensitivity of the method. Minimizing trials may have compromised the sensitivity of this methodology because more trials would have made the violation, or unexpected outcomes, more salient in the subjects' mind and our study lacked this added salience. This design contrasts with other looking time studies which had more success than our own (Erdőhegyi, Gergely & Topál, 2009; Pattison, Miller, Rayburn-Reeves & Zentall, 2010; Pattison, Laude, & Zentall, 2013). The study by Brauer and Call (2011), which measured different behavioral responses to a habituation and dishabituation paradigm, employed fourteen baseline (expected) trials and two surprise (unexpected/violation) trials. This study design allows the subjects to habituate to the expected or baseline trials, thus enhancing the surprise and potentially increasing their duration of looking in unexpected outcomes.

Similarly, other studies employing the violation of expectation or habituation and dishabituation paradigms to study other perceptual abilities in dogs have had success using multiple expected trials, habituation to the expected outcome or shaping before the unexpected trials (Erdőhegyi, Gergely & Topál, 2009; Pattison, Miller, Rayburn-Reeves & Zentall, 2010; Pattison, Laude, & Zentall, 2013). Pattison, Miller, Rayburn-Reeves, and Zentall (2010) investigated dogs' understanding of the physical properties and memory of objects by measuring looking time in a violation of expectation paradigm. Their procedure involved four habituation periods used to familiarize the dogs to their apparatus and the movement of the apparatus. These

trials were followed by two more habituation trials to familiarize dogs with the objects they used in their study (Pattison, Miller, Rayburn-Reeves, and Zentall, 2010). After the habituation trials the dogs participated in six testing trials (Pattison, Miller, Rayburn-Reeves, and Zentall, 2010). The use of multiple habituation and testing trials may have helped the dogs pick up on the changes between an expected and unexpected outcomes. Finally, their experimental set up featured opaque cloths on either side of their apparatus and a cloth for the experimenter to hide from the subject's line of sight behind (Pattison, Miller, Rayburn-Reeves and Zentall, 2010). The use of this opaque covering removed any potential distractions from the subject's vision, thus increasing the likelihood that they would spend time looking at the apparatus rather than around the surrounding areas. Therefore, our dogs could have been distracted to differing degrees. This could explain the large variation we saw in individual looking times (i.e. some dogs may have been distracted by the surrounding areas whereas other may not have been). Future studies may benefit from using an additional measure for auditory distractions during testing trials. Controlling statistically for distraction may help alleviate some of the individual difference seen in looking time.

Erdőhegyi, Gergely, and Topál (2009) employed similar methods to Pattison, Miller, Rayburn-Reeves and Zentall (2010) to investigate dogs' concept of size constancy. Their method featured shaping trials in which dogs were shown the expected condition for six trials and then one unexpected trial (Erdőhegyi, Gergely & Topál, 2009). Looking times from the last shaping trial and the unexpected trial were compared to show significantly longer looking time in the unexpected outcome (Erdőhegyi, Gergely & Topál, 2009). It is possible that Brauer and Call (2011), Pattison, Miller, Rayburn-Reeves and Zentall (2010), and Erdőhegyi, Gergely, and Topál (2009) may have all been more successful using a looking time paradigm because of these

methodological differences. Their success with this method and, most notably, Brauer and Call's (2011) results regarding spatiotemporal and property/kind individuation in dogs suggest that the violation of expectation paradigm is effective for investigating dogs' perceptual abilities. It also suggests that although our study did not find any indication of dogs' capacity to use spatiotemporal, property, and kind information to individuate objects, these abilities may still be present in dogs' repertoire of perceptual and cognitive skills.

The findings of this study suggest that the mechanisms by which humans individuate objects using property/kind information and language may still be unique. Our results show no evidence of dogs using language in ways similar to that of human infants, however, this study was methodologically flawed and careful interpretation of these results is required. The limitations present in this study should be avoided in future research of this topic which remains justifiable and of interest. Future studies may benefit from implementing additional familiarization, habituation or shaping trials into the experimental design. With the addition of these trials, future studies may also require a between subjects design as not to lose the attention of the subjects during multiple trials within each condition. With the addition of these experimental elements, it is possible that future endeavors into this topic will be more effective. Our study was limited by a small sample size, a lack of additional trials, and possible external distractors in our testing room. While we found no significant difference in subjects' looking time between expected and unexpected outcomes, it is likely that this was due to our experimental limitations and future research should continue investigating the use of spatiotemporal, property, and kind information by dogs in object individuation tasks.

References

Bloom, P. (2004). Can a dog learn a word?. *Science*, *304*(5677), 1605-1606. doi: 10.1126/science.1099899

Bräuer, J., & Call, J. (2011). The magic cup: Great apes and domestic dogs (*Canis familiaris*) individuate objects according to their properties. *Journal of Comparative Psychology, 125*(3), 353-361. doi:10.1037/a0023009

Diamond, A. (2001). Looking closely at infants' performance and experimental procedures in the A-not-B task. *Behavioral and Brain Sciences*, *24*(1), 38-41. doi: 10.1017/S0140525X01253916

Erdőhegyi, Á., Gergely, A., & Topál, J. (2009). Using the violation of expectation paradigm in dogs: Does it work?. *Journal of Veterinary Behavior: Clinical Applications and Research*, *4*(2), 48. doi: 10.1126/science.1176960

Fontanari, L., Rugani, R., Regolin, L., & Vallortigara, G. (2014). Use of kind information for object individuation in young domestic chicks. *Animal Cognition, 17*(4), 925-935. doi:10.1007/s10071-013-0725-9

Hauser, M. D., Chomsky, N., & Fitch, W. T. (2002). The faculty of language: What is it, who has it, and how did it evolve? *Science, 298*(5598), 1569-1579. doi:10.1126/science.298.5598.1569

Kaminski, J., Call, J., & Fischer, J. (2004). Word learning in a domestic dog: Evidence for "fast mapping". *Science, 304*(5677), 1682-1683. doi:10.1126/science.1097859

Krøjgaard, P. (2004). A review of object individuation in infancy. *British Journal of Developmental Psychology, 22*(2), 159-183. doi:10.1348/026151004323044555

Mendes, N., Rakoczy, H., & Call, J. (2008). Ape metaphysics: Object individuation without language. *Cognition, 106*(2), 730-749. doi:10.1016/j.cognition.2007.04.007

Pattison, K. F., Laude, J. R., & Zentall, T. R. (2013). The case of the magic bones: Dogs' memory of the physical properties of objects. *Learning and Motivation*, *44*(4), 252-257. doi: 10.1016/j.lmot.2013.04.003

Pattison, K. F., Miller, H. C., Rayburn-Reeves, R., & Zentall, T. (2010). The case of the disappearing bone: Dogs' understanding of the physical properties of objects. *Behavioural Processes*, *85*(3), 278-282. doi: 10.1016/j.beproc.2010.06.016

Phillips, W., & Santos, L. R. (2007). Evidence for kind representations in the absence of language: Experiments with rhesus monkeys (*Macaca mulatta*). *Cognition, 102*(3), 455-463. doi:10.1016/j.cognition.2006.01.009

Rivera, S. M., & Zawaydeh, A. N. (2006). Word comprehension facilitates object individuation in 10- and 11-month-old infants. *Brain Research, 1146*, 146-157. doi:10.1016/j.brainres.2006.08.112

Santos, L. R., Sulkowski, G. M., Spaepen, G. M., & Hauser, M. D. (2002). Object individuation using property/kind information in rhesus macaques (*Macaca mulatta*). *Cognition, 83*(3), 241-264. doi:10.1016/S0010-0277(02)00006-9

Uller, C., Carey, S., Hauser, M., & Xu, F. (1997). Is language needed for constructing sortal concepts? A study with nonhuman primates. In *Proceedings of the 21st annual Boston University conference on language development* (Vol. 21, pp. 665-677). Somerville, MA: Cascadilla Press.

Xu, F. (1995). Criteria for object individuation and numerical identity in infants and adults: the object-first hypothesis *(Doctoral dissertation, Massachusetts Institute of Technology).*

Xu, F. (1999). Object individuation and object identity in infancy: The role of spatiotemporal information, object property information, and language. *Acta Psychologica, 102*(2), 113-136. doi:10.1016/S0001-6918(99)00029-3

Xu, F. (2002). The role of language in acquiring object kind concepts in infancy. *Cognition, 85*(3), 223-250. doi:10.1016/S0010-0277(02)00109-9

Xu, F. (2007). Sortal concepts, object individuation, and language. *Trends in Cognitive Sciences, 11*(9), 400-406. doi:10.1016/j.tics.2007.08.002

Xu, F., & Baker, A. (2005). Object individuation in 10-month-old infants using a simplified manual search method. *Journal of Cognition and Development, 6*(3), 307-323. doi:10.1207/s15327647jcd0603_1

Xu, F., Cote, M., & Baker, A.(2005). Labeling guides object individuation in 12-month-old infants. *Psychological Science, 16*(5), 372-377. doi:10.1111/j.0956-7976.2005.01543.x

Xu, F., & Carey, S. (1996). Infants' metaphysics: The case of numerical identity. *Cognitive Psychology, 30*(2), 111-153. doi:10.1006/cogp.1996.0005

Xu, F., Carey, S., & Quint, N. (2004). The emergence of kind-based object individuation in infancy. *Cognitive Psychology, 49*(2), 155-190. doi:10.1016/j.cogpsych.2004.01.001

Figures and Tables

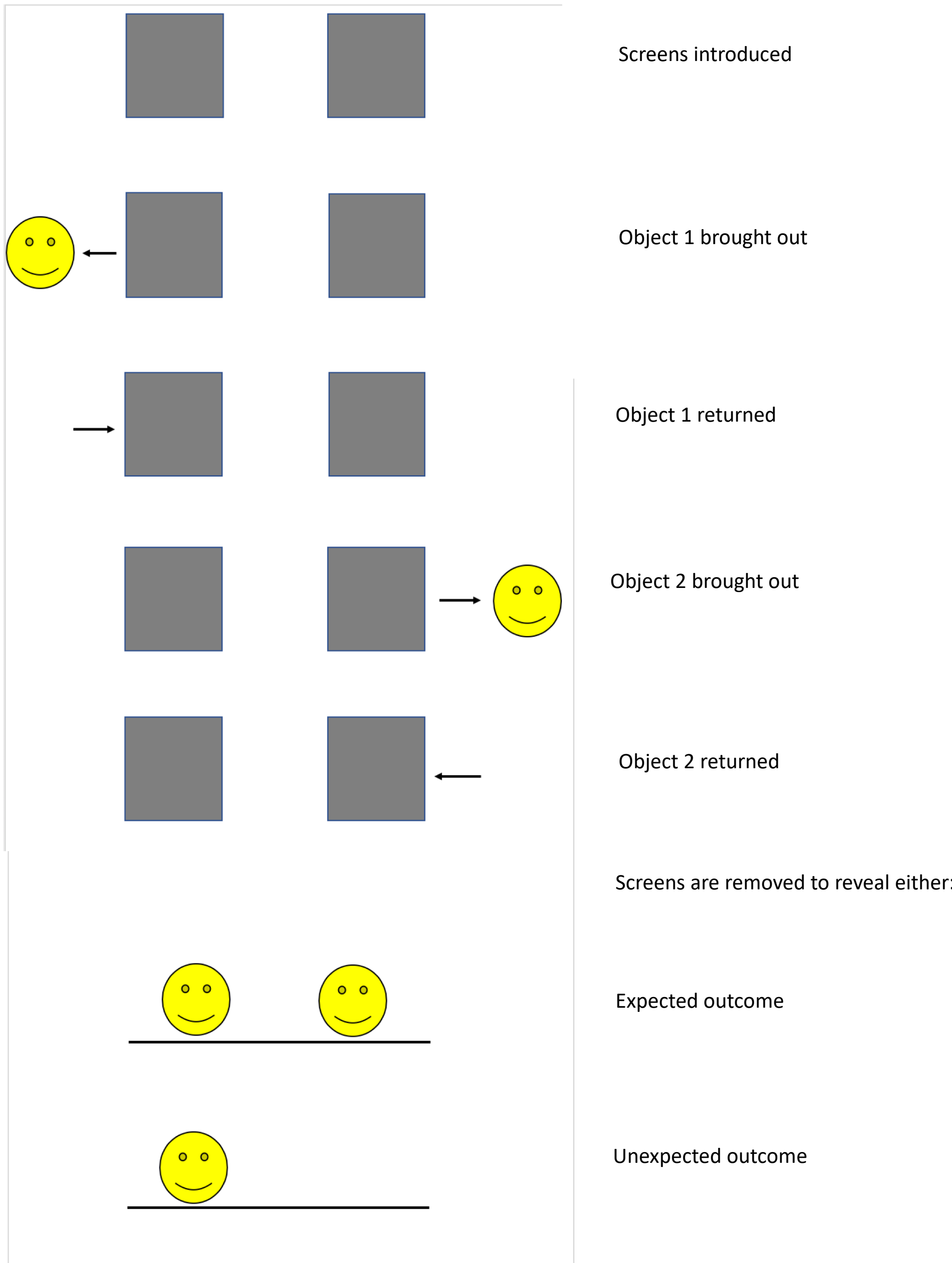

Figure 1. Adapted from Xu & Carey (1996). An example of a display used to assess infants understanding of spatiotemporal information in object individuation. The unexpected condition violates spatiotemporal information as the object apparently passed through the space between the screens and thus informs infants that there must be two objects, one behind each screen.

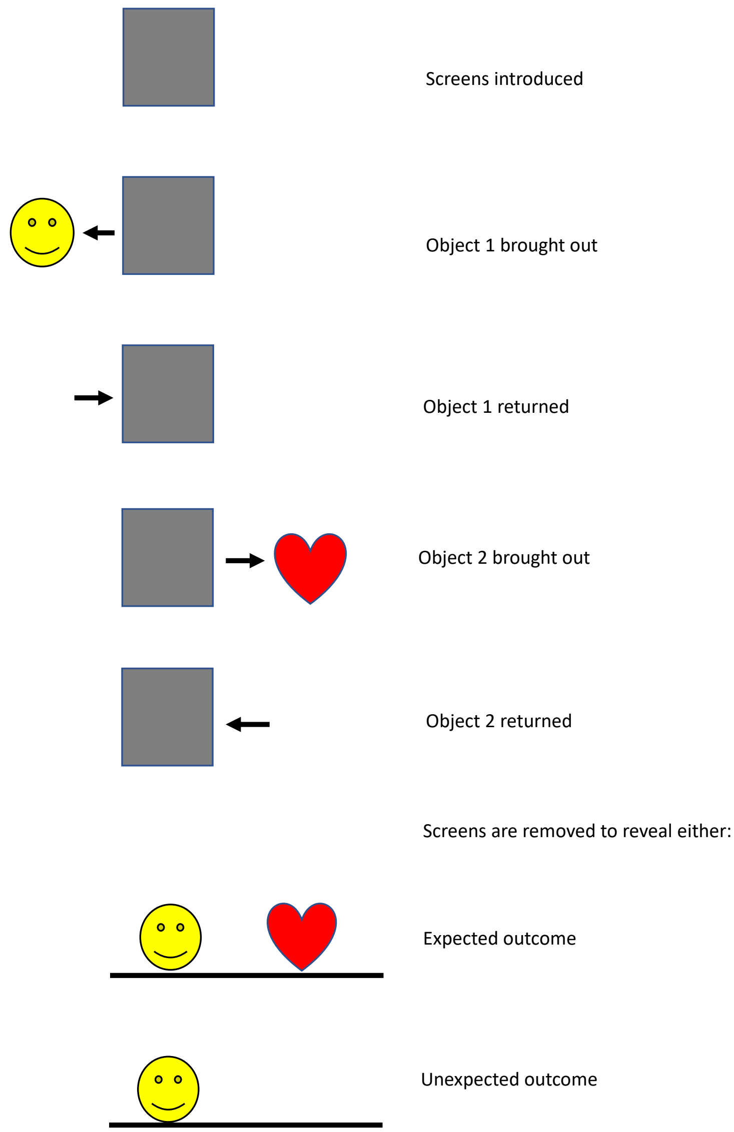

Figure 2. Adapted from Xu & Carey (1996). An example of a display used to assess infants understanding of property information in object individuation. The unexpected condition violates property information as the single object seems to magically transform properties to represent both a heart and a smiley face.

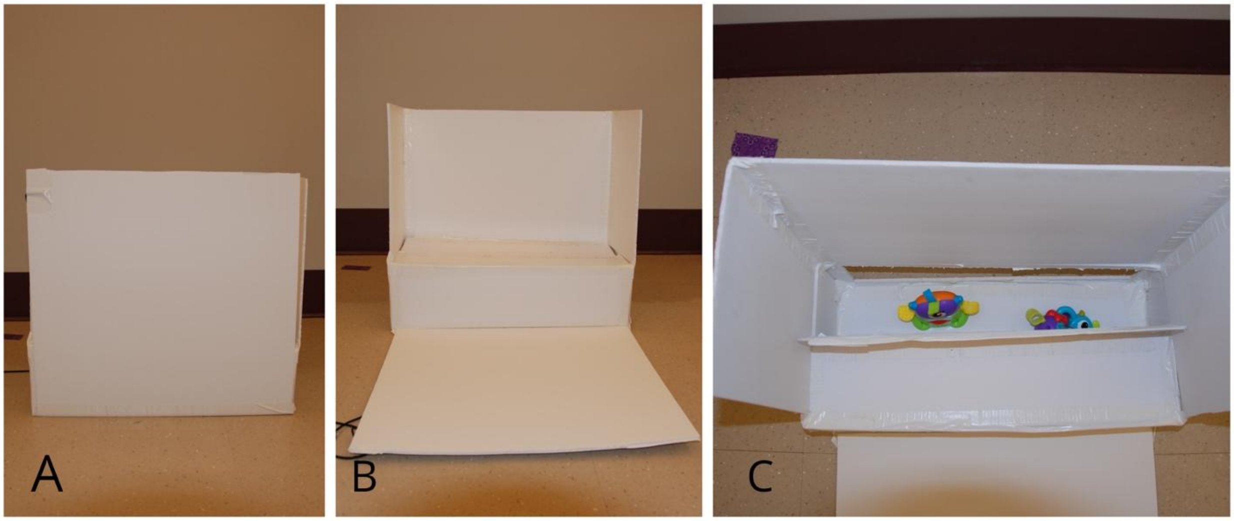

Figure 3. Looking time apparatus. A. Looking time apparatus with the occluder up. This is what dogs see when E2 prepares displays or is surreptitiously removing one of the baby toys. B. The apparatus with the occluder down. This is the stage display where toys sit that dogs see during each trial. C. Overhead view of false bottom in the stage with toys inside false bottom. This is where toys are stored during trials for removal or for the change of a toy type.

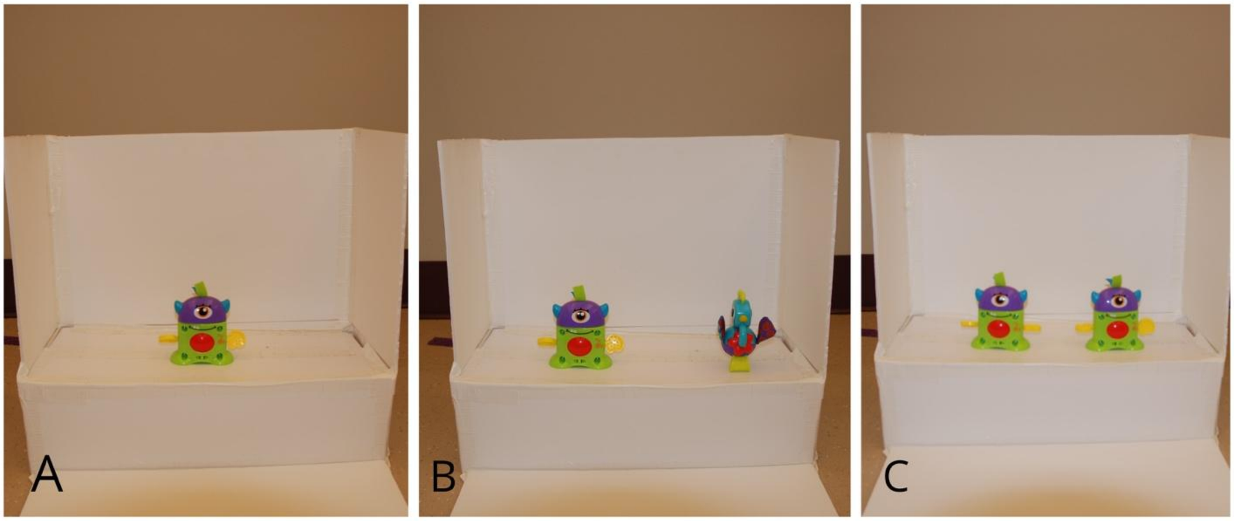

Figure 4. Familiarizations for each condition. B and C are familiarizations for spatiotemporal and property kind trials. B is the expected outcome and C is the unexpected outcomes. A and C are the familiarizations for the kind trial. C is the expected outcome and A is the unexpected outcome.

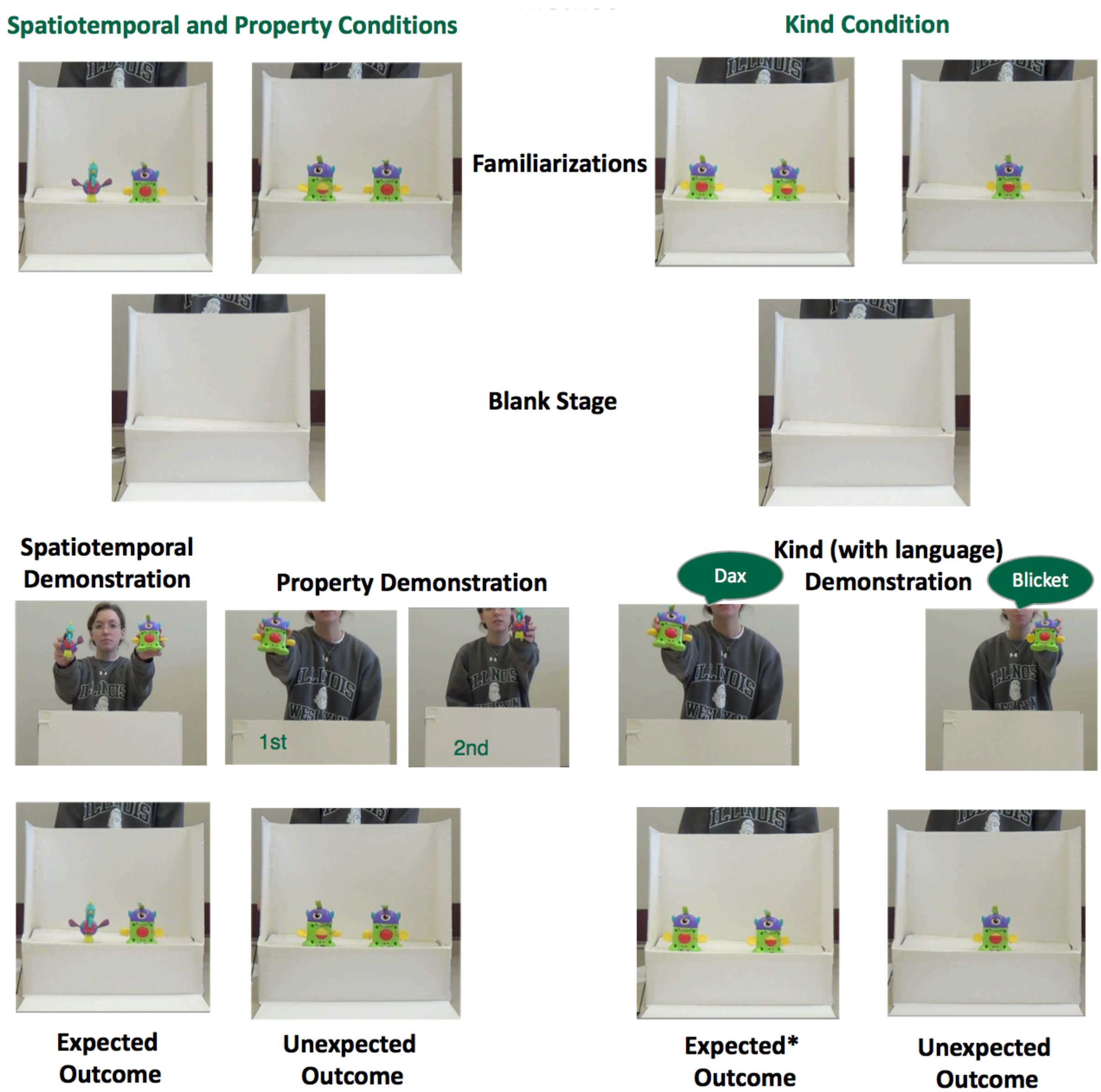

Figure 5. Stills taken from experimental procedure to demonstrate exactly what each subject sees in each condition. Kind without language not represented, however, is it the same procedure as kind with language except toys are not labeled "dax" or "blicket", rather the dog is simple cued by the experiment saying "Dog's name, look". The expected and unexpected outcomes are reversed in the kind without language condition such that the expected outcome is one Harvey toy and the unexpected outcome is two Harvey toys to follow the most parsimonious explanation for the demonstration.

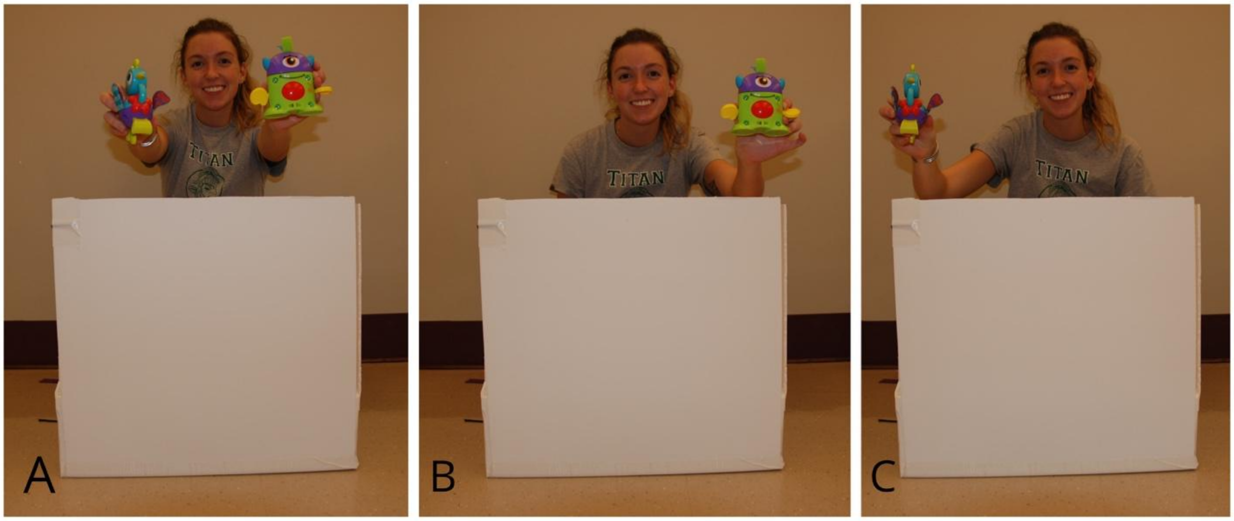

Figure 6. Each display type dogs will see during demonstrations. A. This display is used in the spatiotemporal trials for both the expected and unexpected conditions. The B display is used in the property and the kind conditions. The C display is used in the property condition. B and C are the displays used in the object property and kind trial for both the unexpected and expected. Order of which toy is shown first is counterbalanced, but they always appear on these respective sides.

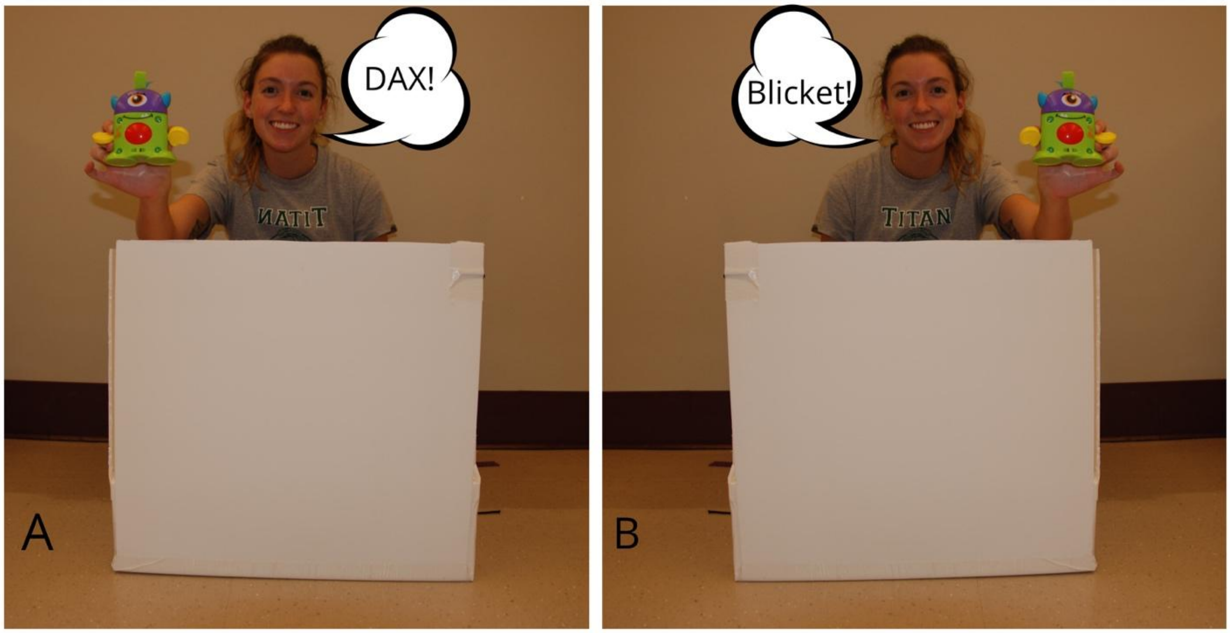

Figure 7. Display for kind trial. E2 showed the same toy twice, but with different labels for it and say either one toy on the display stage in the unexpected condition (Figure 3A) or two toys in the expected conditioned (Figure 3C)

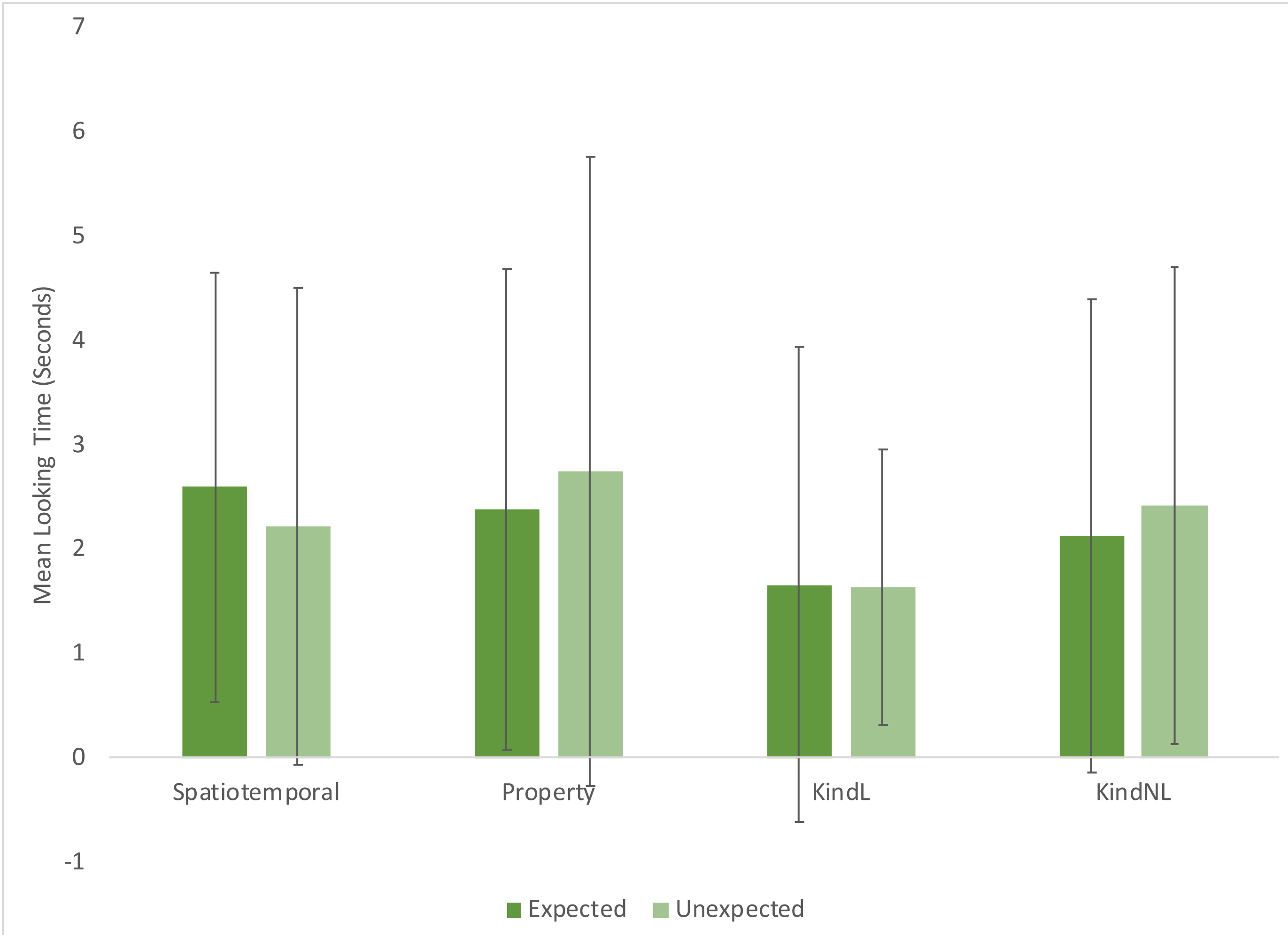

Figure 8. KindL denotes the kind with language condition and KindNL denotes the kind without language condition. Mean looking time, with standard deviations, for the expected and unexpected outcomes of each condition. There was no significant difference between the means of expected and unexpected outcomes for any condition.

Appendix A

Domestic Dog Demographics

IWU Dog Scientist Data Base			
Name	Breed	Sex	Age (in years)
Piper	Labradoodle	Female	4
Layla	Standard Poodle	Female	8
Ginger	Airedale Terrier	Female	9
Tilly	Hound Mix	Female	6
Barkley	Boston Terrier	Male	8
Miley	Golden Retriever	Female	5 Months
Zannie	German Sheppard/Rottweiler Mix	Female	10
Ginger	Lab/Pointer Mix	Female	5
Riley	Maltese/Poodle Mix	Male	8
Kane	Unknown Mix	Male	10
Truman	Golden Retriever	Male	2
Steve	Terrier Mix	Male	11
Mason	West Highland White Terrier	Female	2
Taloo	Lab/Dane Mix	Male	10
Caya	Lab	Female	8
Sweet Dee	Pitbull Mix	Female	9
Tiffany	Golden Retriever	Female	6
Riley	Wheaten/Poodle Mix	Male	5
Patch	Australian Sheppard	Male	10 Months
Buddy	Sheltie	Male	12
Hobbes	Lab Mix	Male	5
Jersey	Lab Mix	Female	2
Baxter	Hound Mix	Male	1
Cleo	Terrier Mix	Female	2